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Imagawa

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[54] **DC ELECTRIC ARC MELTING APPARATUS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **373/108**; 373/43; 373/47; 373/78; 373/102; 373/103; 373/104

[58] **Field of Search** 373/108, 102-104, 373/43, 46, 47-49, 78

[56] **References Cited**

U.S. PATENT DOCUMENTS

993,105	5/1911	Reid	373/43
1,331,625	2/1920	Critchett	373/48
1,913,161	6/1933	Jonas	373/47
3,612,740	10/1971	Gierek	373/78
3,950,601	4/1976	Popov et al.	373/43
4,001,487	1/1977	Schumacher et al.	373/47

FOREIGN PATENT DOCUMENTS

1-167577 7/1989 Japan .

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Assistant Examiner—Tu Hoang
Attorney, Agent, or Firm—William A. Drucker

[57] **ABSTRACT**

Two DC electric arc furnaces are provided side by side. The both DC electric arc furnaces are connected by a duct. Each of two power source apparatuses is mounted near and associated with each of the DC electric arc furnaces. The anodes of the both power source apparatuses are mutually connected by an anode cable and the cathodes of the apparatuses by a cathode cable. The anodes and the cathodes of the both DC elecric furnaces are connected to the anode cable and the cathode cable, respectively, via a connection circuit adapted to supply electric power alternately to either of the DC electric arc furnaces. When a raw material is molten in one of the DC electric arc furnaces, electric power is supplied by the both power source apparatuses to this DC electric arc furance. The exhaust gas at a high temperature produced in this DC electric arc furnace is sent to the other DC electric arc furnace through the duct and preheats another raw material charged there beforehand.

1 Claim, 2 Drawing Sheets

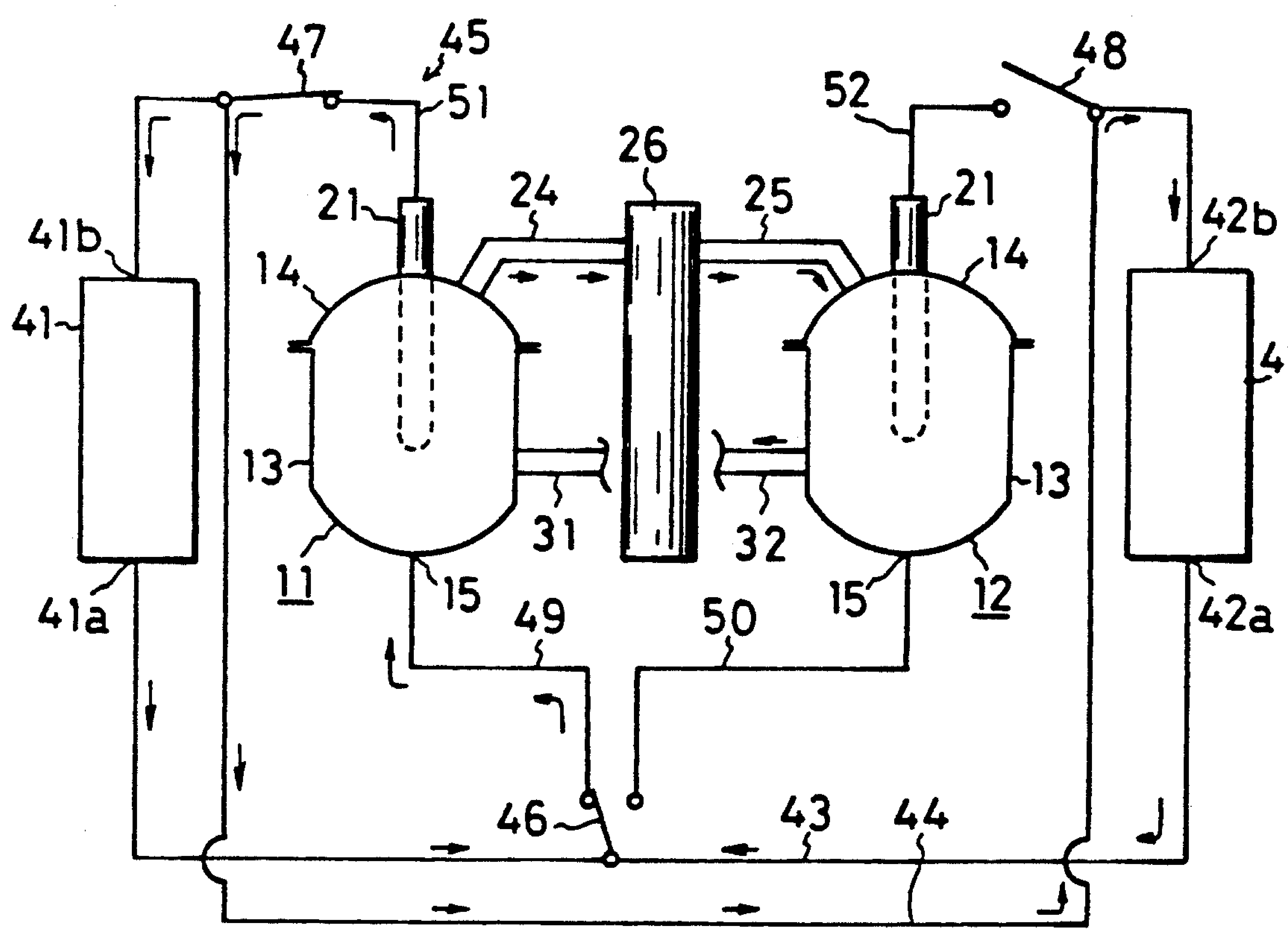

FIG. 1

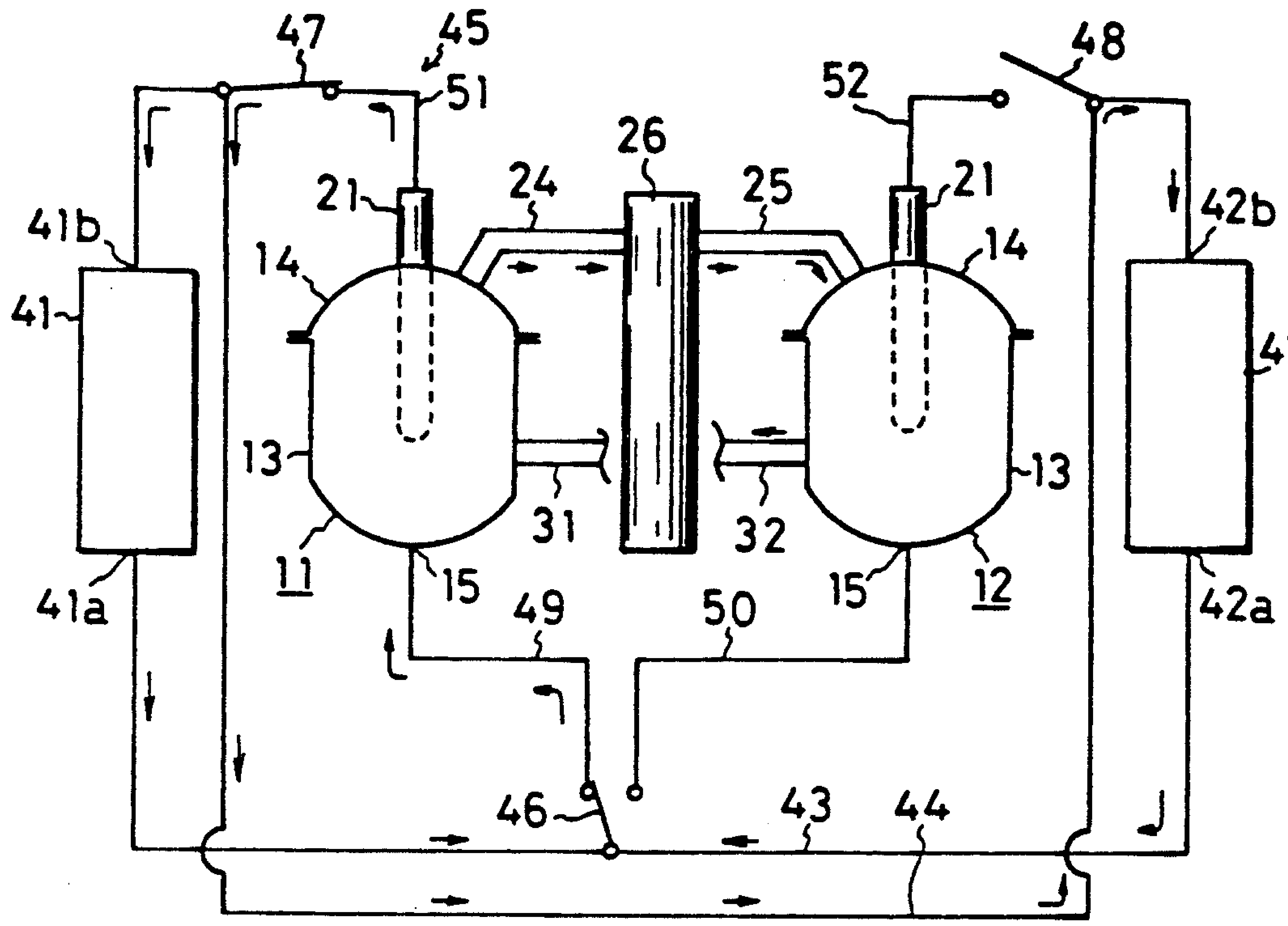
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FIG. 2

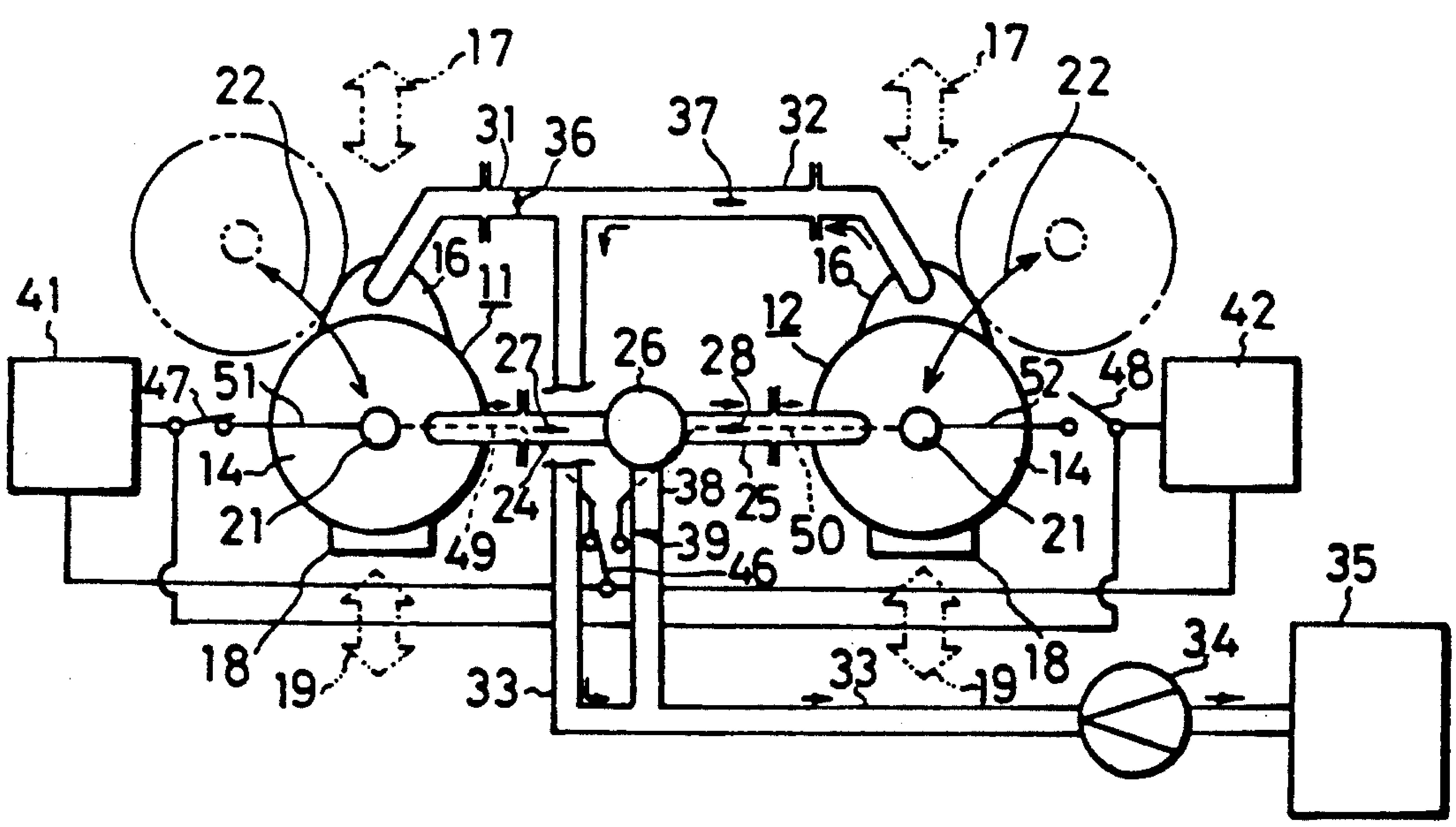
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FIG. 3

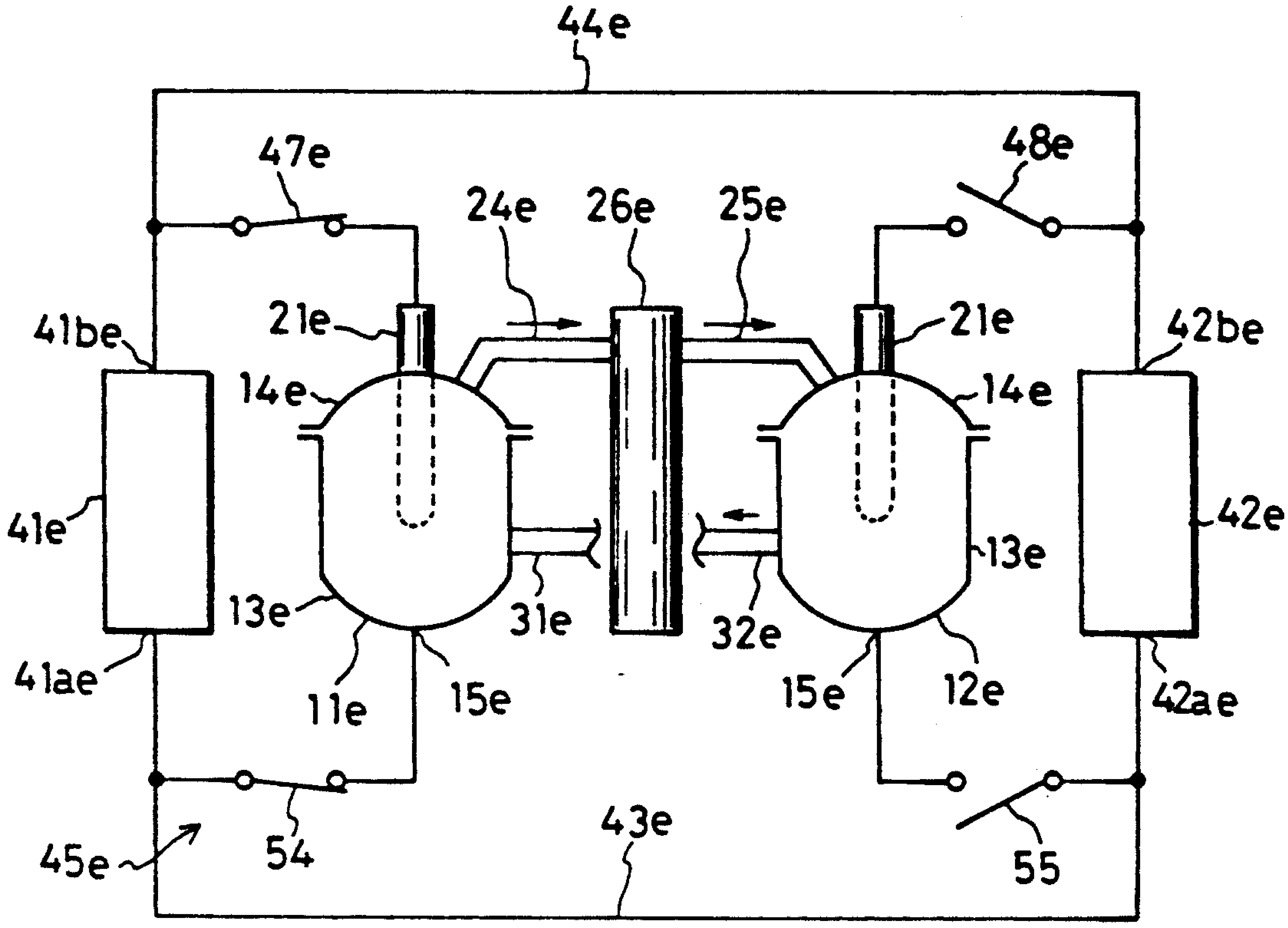
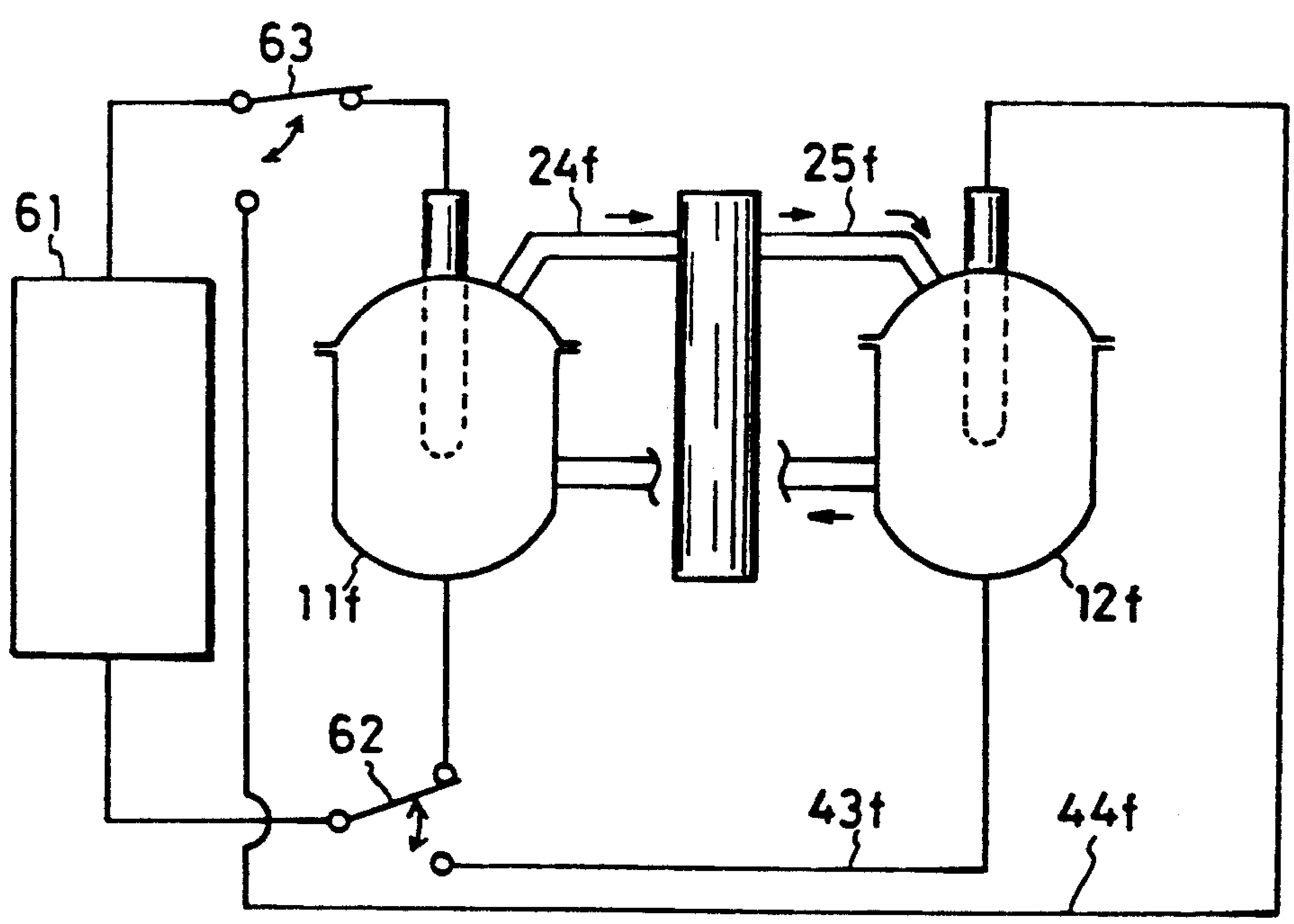


FIG. 4 (PRIOR ART)



DC ELECTRIC ARC MELTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a DC electric arc melting apparatus to melt various raw materials by electric arc heating.

2. Description of the Prior Art

In order to melt raw materials, a DC electric arc furnace, for example, is used. When the raw materials are molten in the DC electric arc furnace, exhaust gas at a high temperature is produced there. There is a technique to effectively utilize the heat of the exhaust gas. Namely, in addition to a DC electric arc furnace **11***f* including a power source apparatus **61**, another DC electric arc furnace **12***f* is additionally provided and the both furnaces are connected by ducts **24***f* and **25***f* as shown in FIG. **4**. The exhaust gas at a high temperature produced in the first DC electric arc furnace **11***f* in melting operation is sent to the second DC electric arc furnace **12***f* through the ducts **24***f* and **25***f*. In the second DC electric arc furnace **12***f*, a raw material charged beforehand is preheated by utilizing the heat of the exhaust gas. After the melting operation in the first DC electric arc furnace **11***f* is finished, the melting operation in the second DC electric arc furnace is performed. In this case, the power source apparatus **61** of the first DC electric arc furnace **11***f* is utilized as that for the second furnace. Namely, change-over switches **62** and **63** are interposed in a connection circuit between the power source apparatus **61** and the first DC electric arc furnace **11***f*. These switches **62** and **63** are connected to the second DC electric arc furnace **12***f* by an anode cable **43***f* and a cathode cable **44***f*, respectively. Electric power is supplied from the power source apparatus **61** to the second DC electric arc furnace **12***f* by changing over the switches **62** and **63**. The melting operation in the second DC electric arc furnace **12***f* can be performed with less electric energy since the raw material there has already been preheated. Again in this case, the exhaust gas at a high temperature produced in the second DC electric arc furnace **12***f* is sent into the first DC electric arc furnace **11***f* through the ducts **25***f* and **24***f* and is used for the preheating there. The above mentioned technique to utilize the exhaust gas for the preheating is disclosed, for example, in a Japanese published unexamined patent application No. 1-167577.

Now, the above mentioned both DC electric arc furnaces **11***f* and **12***f* are connected by the ducts **24***f* and **25***f*, each DC electric arc furnace is provided with a tap hole and a slagging door, and a furnace roof elevating and swinging apparatus is provided close to each electric arc furnace. Furthermore, spaces for works of tapping out molten metal and slag and repairing the furnace are necessary around each furnace.

According to the technique shown in FIG. **4**, however, a power source apparatus capable of supplying 100% of the operating power of any one of the DC electric arc furnaces as the power source apparatus **61**. There appears a problem that such a power source apparatus is large-sized and therefore is difficult to be mounted around the furnace having the above mentioned various spatial restrictions. Moreover, the full current to operate the second DC electric arc furnace **12***f* flows through the anode cable **43***f* and the cathode cable **44***f* connecting the DC electric arc furnace **12***f* to the switches **62** and **63**, respectively and so these cables have to have a sufficiently large cross section to pass the full operating current. Cables having a large cross section are expensive. Furthermore, the work of laying the cables is difficult. Namely, the cables must be laid at places kept away from the above mentioned ducts **24***f* and **25***f*, the tap hole, the slagging door and the spaces for the above mentioned works. Consequently, the cables must be bent and be supported at various points. The work of bending and supporting the cables having a large cross section is extremely difficult since these cables are less flexible and heavy.

SUMMARY OF THE INVENTION

A first object of the present invention is to provide a DC electric arc melting apparatus wherein when a raw material is molten in a first DC electric arc furnace, another raw material in a second DC electric arc furnace can be preheated, at a place causing the least loss of heat and as close as possible to the first furnace, by making use of the exhaust gas at a high temperature produced in the first DC electric arc furnace. When such preheating is available, there is a usefulness that the melting operation of the preheated raw material in the second DC electric arc furnace can get off with less electric energy than that of a cool raw material.

A second object of the present invention is to provide a DC electric arc melting apparatus wherein when electric power is supplied to the first DC electric arc furnace for the melting operation there, the electric power is supplied not only by the power source apparatus for the first DC electric arc furnace but also by the power source apparatus for the second DC electric arc furnace where the raw material is preheated but any electric power is not consumed.

When not only the power source apparatus for the first DC electric arc furnace but also that for the second DC electric arc furnace can be utilized in this manner, there is an advantage that a cheap power source apparatus with an output equal to a half of the operating electric power of the first DC electric arc furnace suffices as the power source apparatus for the first DC electric arc furnace.

A third object of the present invention is to provide a DC electric arc melting apparatus wherein when the raw material is molten in the second DC electric arc furnace, by contrast to the case of the above mentioned objects, as well, the raw material can be preheated in the first DC electric arc furnace by making use of the exhaust gas produced in the second DC electric arc furnace. The third object is as well to provide a DC electric arc melting apparatus wherein when electric power is supplied to the second DC electric arc furnace for the melting operation there, the electric power is supplied not only from the power source apparatus for the second DC electric arc furnace but also from the power source apparatus for the first DC electric arc furnace and, in addition, a power source apparatus with an output equal to a half of the operating electric power of the second DC electric arc furnace suffices as the power source apparatus for the second DC electric arc furnace.

A fourth object of the present invention is to provide a DC electric arc melting apparatus wherein the power source apparatuses, provided for the first and second DC electric arc furnaces, respectively, are small-sized and can be mounted in a small empty space available around each of the DC electric arc furnaces.

Either of the power source apparatuses for the first and second DC electric arc furnaces is small-sized since the power source apparatuses have only to have an output equal to a half of the operating electric power of the DC electric arc furnace as is mentioned above. Accordingly, there is an advantage that even though the use of the space around the DC electric arc furnace is restricted due to the above mentioned tap hole and slagging door and the spaces for the works, the small-sized power source apparatuses can be mounted in a small empty space apart from such members and the spaces for the works. In other words, this is a feature that the small-sized power source apparatus, mounted in such small empty space, do not interfere at all with the works around the furnaces.

A fifth object of the present invention is to provide a DC electric arc melting apparatus wherein, among the power supply cables connecting the DC electric arc furnaces to the power source apparatuses, the anode cable connecting the anodes of the both power source apparatuses and the cathode cable connecting the cathodes of them can be both relatively thin.

In order to supply electric power to the first and second DC electric arc furnaces in the above mentioned manner, the anode cable connecting the anodes of the both power source apparatuses and the cathode cable connecting the cathodes of them are necessary. According to the present invention, however, when either the first or the second DC electric arc furnace is operated, half the operating electric power necessary for the operated DC electric arc furnace is supplied by the power source apparatus for the operated DC electric arc furnace and the other half is supplied by the power source apparatus for the other DC electric arc furnace through the above mentioned anode and cathode cables. Namely, only half the full current necessary for operating the DC electric arc furnaces flows in the anode and cathode cables. Consequently, these anode and cathode cables have only to have half the cross section necessary for passing the full operating current. Namely, the cables may be thin. Such thin cables are cheap and the work of laying the cables is easy.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation showing schematically the positional relationship of various members in a first embodiment of a DC electric arc melting apparatus;

FIG. 2 is a plane view of the DC electric arc melting apparatus of FIG. 1;

FIG. 3 is a front elevation showing schematically the positional relationship of various members in a second embodiment of the DC electric arc melting apparatus; and

FIG. 4 is a front elevation showing schematically the positional relationship of various members in a conventional DC electric arc melting apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. 1 and 2, a first and a second DC electric arc furnaces **11** and **12** are provided side by side. These DC electric furnaces **11** and **12** are located as close to each other as possible so that when the exhaust gas produced in one of the DC electric arc furnaces is sent to the other as is described hereinafter, the heat loss from the gas may be the least. Each DC electric arc furnace **11** or **12** includes a furnace body **13** and furnace roof **14** covering it. A bottom electrode (anode) **15** is mounted in a hearth bottom of the furnace body **13**. The furnace body **13** is formed, at a part of the side wall thereof, with a protrusion **16** and is provided with a tap hole under the protrusion **16**. Under the tap hole, ladle for taking out molten metal put on a truck is carried in or out in the direction shown by an arrow **17**. The furnace body **13** is formed with a slagging door **18** at another part of the side wall of the body **13**, for example, at the part opposite to the protrusion **16** as shown. The works of taking out slag and repairing the furnace are performed through the slagging door **18** and along the direction shown by an arrow **19**. A top electrode (cathode) **21** is mounted in the furnace roof **14**. The furnace roof **14** is moved to a retreat place shown by alternate long and two short dash lines or is put again onto the furnace body **13** in the direction shown by an arrow **22** by a well known furnace roof elevating and swinging apparatus not shown.

One end of a preheating duct **24** or **25** is connected to the furnace roof **14** of the DC electric arc furnace **11** or **12**. The other ends of the preheating ducts **24** and **25** are connected to a combustion tower **26** provided between the DC electric arc furnaces **11** and **12** and the ducts **24** and **25** communicate with each other through the combustion tower **26**. Each preheating duct **24** or **25** is provided therein with a damper **27** or **28**. One end of an exhaust duct **31** or **32** is connected to the protrusion **16** in the DC electric arc furnace **11** or **12**. The other ends of these exhaust ducts **31** and **32** are connected to a common exhaust duct **33**. The exhaust duct **33** is connected to a dust collector **35** via a blower **34**. The exhaust duct **31** or **32** is provided therein with a damper **36** or **37**. The combustion tower **26** is connected to the exhaust duct **33** by a by-pass duct **38** including therein a damper **39**.

Now an electric system is described. A power source apparatus **41** or **42** is mounted near each DC electric arc furnace **11** or **12**. These power source apparatuses are those which are adapted to transform AC input power into DC output power with use of thyristors. Half the operating electric power of one DC electric arc furnace i.e. the DC electric furnace **11** or **12** is sufficient as the output of each power source apparatus **41** or **42**. Anodes **41*a*** and **42*a*** of the both power source apparatuses are connected to each other by an anode cable **43**. Cathodes **41*b*** and **42*b*** are connected to each other by a cathode cable **44**. As these cables **43** and **44**, those cables are used which have a cross section sufficient for passing only half the full operating current of the DC electric arc furnace **11** or **12**. The first DC electric arc furnace **11** and the second one **12** are connected to the cables **43** and **44** through a connection circuit **45** which is adapted to supply electric power interchangeably to the DC electric furnace **11** or **12**. In the present embodiment, the connection circuit includes three switches **46**, **47** and **48** for change-over operation. As the switch **46**, a change-over switch is used and is located at the midway point between the both DC electric arc furnaces **11** and **12**. On the other hand, simple making and breaking switches are used as the switches **47** and **48** which are located near the top electrodes **21** of the first and second DC electric arc furnaces **11** and **12**, respectively. Numerals **49** through **52** represent connection cables connecting respective switches to the bottom electrodes **15**, the anodes of the DC electric arc furnaces and to the top electrodes **21**, the cathodes of the furnaces. As these cables **49** through **52**, those cables are used which have a cross section sufficient for passing the operating full current.

In the next place, the operation of the DC electric arc melting apparatus is explained. First of all, the first DC electric arc furnace **11** is operated as follows. A raw material such as a scrap raw material or a reduced iron material is charged into the first DC electric arc furnace **11**. The work of charging the raw material is performed with the furnace roof **14** opened as is well known. The raw material to be charged may be either preheated or not. On the other hand, a raw material not preheated is charged into the second DC electric arc furnace **12**. The switches **46** through **48** are changed over beforehand to the states shown in the figures and the dampers **27**, **28**, **36**, **37** and **39** are kept in the states shown in the figures. With these states, the both power source apparatuses **41** and **42** are turned on. Then the DC electric power output by the both power source apparatuses **41** and **42** is supplied to the first DC electric arc furnace **11**. An electric arc is struck by the supplied electric power in the first DC electric arc furnace **11** and the charged raw material is molten by the heat produced by the electric arc. While the melting operation in the first DC electric arc furnace **11** proceeds in this manner, exhaust gas at a high temperature is produced. The exhaust gas is sent to the second DC electric arc furnace **12** through the ducts **24** and **25**. In the second DC electric arc furnace **12**, the raw material charged beforehand is preheated by the supplied exhaust gas. The exhaust gas, which has been made use of for the preheating, is sent to the dust collector **35** through the ducts **32** and **33**. In this case, the amounts of opening of the respective dampers are adjusted so that a suitable amount of the exhaust gas from the first DC electric arc furnace **11** may flow to the second DC electric arc furnace **12** for the preheating and the rest of the exhaust gas may flow to the dust collector **35** without going to the second DC electric arc furnace **12**. The above mentioned flow of the exhaust gas is formed, of course, by the operation of the blower **34**.

In the case of the melting operation in the first DC electric arc furnace **11**, the raw material may be additionally charged as occasion demands. After the melting operation in the first DC electric arc furnace **11** is finished, the both power source apparatuses **41** and **42** are turned off and the molten metal in the first DC electric arc furnace **11** is tapped out through the tapping hole. The first DC electric furnace **11** is repaired as occasion demands.

After the operation in the first DC electric arc furnace **11** is finished in the above mentioned manner, the operation in the second DC electric arc furnace **12** is successively performed as follows in the same manner as in the case of the first DC electric arc furnace **11**. A new raw material is first charged into the first DC electric arc furnace **11**. The switches **46** through **48** are changed over to the states opposite to those shown in the figures. The dampers **36** and **37** are turned to the states opposite to those shown in figures. With these states, the power source apparatuses **41** and **42** are again turned on. Then the DC electric power output by the both power source apparatuses **41** and **42** is supplied to the second DC electric arc furnace **12**, where the raw material is molten. The exhaust gas at a high temperature produced at this time is sent to the first DC electric arc furnace **11** through the ducts **25** and **24** and the raw material having been charged beforehand in the first DC electric arc furnace **11** is preheated by the exhaust gas. The exhaust gas, which has been made use of for the preheating, is sent to the dust collector **35** through the ducts **31** and **33**.

When the raw material is molten in the second electric arc furnace **12**, a less electric energy is sufficient for melting the raw material since the raw material has been preheated to a raised temperature. After the melting operation in the second DC electric arc furnace **12** is finished, the both power source apparatuses **41** and **42** are turned off and the molten metal in the second DC electric arc furnace **12** is tapped out.

The above mentioned operations in the first DC electric arc furnace **11** and in the second one **12** are repeated alternately.

In the next place, a different embodiment of the present invention is shown in FIG. **3**. In this embodiment, a connection circuit between an anode cable **43***e* and anodes **15***e* of first and second DC electric arc furnaces includes two switches **54** and **55** instead of the aforementioned change-over switch **46**. In this embodiment, when the first DC electric arc furnace **11***e* is operated, the switches **47***e* and **54** are made and the switches **48***e* and **55** are broken. On the other hand, when the second DC electric arc furnace **12***e* is operated, the switches **47***e* and **54** are broken and the switches **48***e* and **55** are made. Those members in the present embodiment which are considered to be equivalent in view of construction and operation are given the same reference numerals but with an alphabet "e" as those of the corresponding members in the previous embodiment and the explanation of the members is not repeated.

What is claimed is:

1. A DC electric arc melting apparatus comprising first and second DC electric arc furnaces provided with respective anodes and cathodes and being provided side by side, and a duct connecting said first and second DC electric arc furnaces to conduct an exhaust gas from said first DC electric arc furnace to said second one and vice versa, characterized in that power source apparatuses each having an output equal to a half of the operating electric power of said each DC electric arc furnace are located near the first and second DC electric arc furnaces respectively, anodes of said both power source apparatuses are connected mutually by an anode cable, cathodes of said both power source apparatuses are connected mutually by a cathode cable, and said anodes and cathodes of said first and second DC electric arc furnaces are connected to said anode cable and said cathode cable, respectively, through a connection circuit having a switch adapted to supply electric power alternately to either of said first and second DC electric arc furnaces.

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